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DRAWINGS ATTACHED

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(54) VARIABLE INDUCTION DEVICE

(71) We, MAGNETECH INDUSTRIES, INC., a company organised under the laws of the State of Pennsylvania, of 3 Public Avenue, Montrose, Pennsylvania, 18801, U.S.A., do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a variable induction device, and more particularly, to a variable induction device providing an output voltage which may be continuously varied between a predetermined minimum and maximum.

Among the more common types of variable transformers are the conventional autotransformer and transformers utilizing tap changing systems. The autotransformer is similar to a potentiometer in that a continuously variable output voltage is "picked-off" a transformer winding by a sliding contact. The use of a tap changing system to provide a variable output voltage requires the selective making and breaking of contacts connected at desired points along a transformer winding. Both types of variable transformers are subject to mechanical wear and do not provide a truly continuous output voltage, i.e. the output voltage varies incrementally with these types of systems.

In another type of variable transformer, as exemplified by United States patent No. 1,004,102 to Storer, the output voltage is varied by varying the number of secondary winding turns in series aiding and in series opposition with a generator. This is accomplished in the device illustrated in the Storer patent by providing a secondary winding in series with an a.c. generator which is wound in series opposition on two reels and which is transferred from one reel to the other when the reels are rotated. A primary winding, connected across the generator output terminals, is wound on the core about which the reels rotate and is therefore magnetically coupled to the transferable winding. The output voltage is taken between one end of the secondary winding and one side of the generator, the connections to the secondary winding being made through commutators which cooperate with a great number of brushes to prevent arcing.

Since the transferable secondary windings are connected in series opposition, the voltage induced in the winding on one of the reels adds to the generator voltage and the voltage induced in the winding on the other reel subtracts from the generated voltage. Thus, when the entire secondary transformer winding is transferred to the additive reel, the total output voltage is equal to the generator voltage plus the voltage across the secondary winding. Likewise, when the entire secondary transformer winding is transferred to the subtractive reel, the total output voltage is equal to the generator voltage minus the voltage across the secondary winding.

The device disclosed in the Storer patent is thus, in effect, a device for regulating the output voltage of a generator by varying the impedence between the generator output terminals and the load. Line isolation, i.e. isolation between the generator and the load, is not provided and, in addition, the magnetizing current at the full voltage condition is supplied by only one of the primary transformer windings, causing an unbalance in the primary circuit at full voltage. Furthermore, the Storer device does not provide the versatility required in many applications.

It is an object of the present invention to provide a variable induction device having a transferable secondary winding which is electrically isolated from the primary circuit and in which the primary circuit is balanced in the maximum output voltage condition.

It is another object of the present invention to provide a variable induction device which is versatile and may be easily converted for use in a variety of applications.

According to the present invention there is provided a variable induction device comprising a core of magnetic material having two substantially parallel legs, a substantially cylindrical member non-rotatably mounted in each of the legs, a substantially cylindrical, substantially hollow drum coaxially mounted on each of the members for axial rotation thereabout, a first electrically conductive coil having a predetermined number of fixed turns wound in a predetermined direction about one of the drums, electrical contact means carried by one end of each of the drums for rotation therewith, one of the said contact means being electrically connected to one end of said first coil, an electrically conductive commutator carried by each of the legs in wiping engagement with the contact means, a second electrically conductive coil having a predetermined number of turns wound about said drums, the said turns being transferable from one of the drums to the other of the drums in response to the rotation of the drums, one end of the second coil being electrically connected to the other end of the said first coil, the other end of the second coil being electrically connected to the other one of the contact means, a transformer winding carried by the cylindrical members in electrical isolation from the first and second coils and in magnetic flux linking relation thereto, and means for simultaneously axially rotating the drums about the cylindrical members to selectively modify the number of turns in the first coil effective to produce an output voltage by transferring the turns of the second coil from one drum to the other.

The invention also includes a variable induction device comprising a magnetic core, two spaced drums each mounted for axial rotation on said core, an electrically conductive coil having a predetermined number of fixed turns wound in a predetermined direction on one of the drums, a transformer winding carried by the core in electrical isolation from the coil for generating a cydically varying magnetic flux linking the said coil, means for axially rotating the drums, and a coil wound on both drums for selective transference from one drum to the other in response to the rotation of the drums for modifying the number of turns of the electrically conductive coil effective to produce an output voltage.

DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the present invention is illustrated in the accompanying drawings, in which:

Figure 1 is a perspective view of the induction device of the present invention;

Figure 2 is an exploded view of the device of Figure 1;

Figure 3 is an elevational view of the device of Figure 1;

Figure 4 is a cross-sectional view of the device along the line 4-4 in Figure 3;

Figure 5 is a detail view partially in cross section illustrating the commutator of the device of Figure 1;

Figure 6 is a cross-sectional view of the commutator taken along the line 6-6 in Figure 5; and

Figure 7 is a schematic diagram of the induction device of Figure 1.

DETAILED DESCRIPTION

Referring to Figure 1, the induction device of the present invention comprises a rectangular laminated core 10 having a removable end member 12, two generally cylindrical, substantially hollow drums 14A and 14B carried by opposite legs of the core 10 for axial rotation about the longitudinal axes thereof, two electrically conductive coils 16A and 16B formed by a flexible conductor 18 wound about each of the drums 14A, 14B, and means for simultaneously modifying the number of turns in each of the coils 16, 16B. Electrically conductive contacts or brushes 20A and 20B are connected to one end of an associated one of the drums 14A and 14B, respectively, in wiping engagement with an associated one of the commutators 22A and 22B whcih are non-rotatably carried by opposite legs of the core 10. Although not shown in Figure 1, two cylindrical members 24A and 24B are carried by opposite edges of the core 10 within the drums 14A and 14B, respectively, to provide a means for generating a cyclically varying magnetic flux linking the coils 16A, 16B or alternatively to generate an output voltage in response to a cyclically varying magnetic field generated by the coils 16A, 16B.

A more detailed understanding of the construction of the device of the present invention may be had by reference to the exploded view of Figure 2. As shown in Figure 2, the core 10 preferably comprises a pair of spaced substantially parallel laminated legs 26A and 26B of any suitable cross-sectional shape. Illustratively, suitable cross-sectional shapes may include square, rectangular, cruciform, or octagonal shapes.

The adjacent ends of the legs 26A and 26B may be interconnected by a pair of transverse laminated end members 12. Slots 27 are provided to receive the commutators 22A, 22B as will hereinafter be described. This may be accomplished, as

illustrated, by shortening a selected number of laminations which form the legs 26A and 26B.

The end member 12 may be connected to the legs 26A and 26B in any conventional manner, such as by means of pins 28. In this manner, one of the end members 12 may be removed from the legs 26A and 26B to facilitate the assembly and the removal of the various elements comprising the induction device. Greater versatility is thereby achieved as will hereinafter be described.

Referring back to Figure 1, each of the drums 14A and 14B of electrically non-conductive material may be provided with a generally circumferential, helical groove 30 extending from one end of each drum 14A, 14B to the other end thereof along the external surface thereof. The electrical conductor 18 generally conforms to the shape of the grooves 30 and is wound about both of the drums 14, 14B in the grooves 30 to provide the two electrically conductive coils 16A and 16B, the turns of which are transferable from one drum 14 to the other by axially rotating the drums 14A, 14B in synchronism through a timing belt 32. Any suitable conventional level wind mechanism may be utilized as an alternative to the groove 30 if desired.

As is more clearly illustrated in Figure 3, the timing belt 32 engages gear teeth 34 provided on a flange 36 at either or both ends of each of the drums 14A, 14B. The timing belt 32 may also engage a gear 38 which may in turn be driven either manually or by a motor (not shown). The timing belt 32 circumscribes the gear 38 and the flanges 36 at the end of the drums 14A, 14B, thereby providing synchronous axial rotation of the drums 14A, 14B in response to the rotation of the gear 38. Suitable stops (not shown) such as limit switches or mechanical stops may be provided to prevent the motor from driving the drums 14 beyond predetermined limits.

Referring back to Figure 2, the electrically conductive contacts or brushes 20A and 20B are connected to one end of an associated one of the drums 14A and 14B.

One of the drums for example, the drum 14B, is provided with an electrically conductive fixed coil 40 wound thereabout and preferably embedded beneath the surface thereof as illustrated in Figures 2 and 4. In the preferred embodiment of the present embodiment the number of turns of the fixed coil 40 is equal to the total number of turns of the coils 16A and 16B formed by the conductor 18 on the respective drums 14A and 14B. One end 42 of the fixed coil 40 is con- One end 42 of the fixed coil 40 is connected to the end of the overlying coil 16B and the other end 44 of the fixed coil 40 is connected to the brush 20B as illustrated in phantom in Figure 4. The end of the coil 16A on the drum 14A is connected to the brush 20A, also illustrated in phantom in Figure 4.

Referring again to Figures 2 and 4, the cylindrical members 24A and 24B are electrically non-conductive material, are each provided with a longitudinal cavity 46A, 46B respectively generally conforming to the shape of the legs of the core 10, thereby allowing the cylindrical members 24A and 24B to be non-rotatably carried by the legs 26A and 26B, respectively. Each of the cylindrical members 24A and 24B may be provided with circumferential flanges 48 at each end thereof, as well as a circumferential flange 50 intermediate the ends thereof. The flanges 48 at one end of each of the cylindrical members 24 may be provided with a plurality of internally threaded apertures 52 to facilitate the assembly of the induction device as will hereinafter be described. Additionally, a shoulder 54A, 54B extending radially outwardly beyond the flanges 48 may be provided at the other end of each of the cylindrical members 24A and 24B.

The circumferential surfaces of the flanges 48 and 50 are preferably very smooth to provide substantially friction-free bearing surfaces upon which the drums 14A, 14B may be carried for rotation. The shoulder 54A, 54B provided on the flanges 48 at one end of each of the cylindrical members 24A, 24B is also preferably smooth to provide a relatively friction-free surface against which the drums 14A, 14B may abut, as will be more fully described.

As illustrated more clearly in Figure 4, each of the cylindrical members 24A and 24B is provided with a primary transformer winding 56A and 56B, wound thereabout preferably beneath the surface thereof. The respective ends 58A and 60A of the primary transformer winding 56A and the ends 58B and 60B of the primary transformerd winding 56B protrude through suitable lead ports in the respective ends of the cylindrical members 24A and 24B and extend axially therebeyond as illustrated in phantom.

Secondary transformer windings 62A and 62B wound in overlying relationship with the primary transformers windings 56A and 56B respectively may also be provided on the respective cylindrical members 24A and 24B. The ends 64A and 66A of the secondary transformer winding 62A and the ends 64B and 66B of the secondary transformer winding 62B may liksewise protrude through and extend axially beyond the ends of the respective cylindrical members 24A and 24B.

The ends 58A, 58B and 64A, 64B of the primary and secondary transformer

windings 56A, 56B and 62A, 62B respectively also extend through suitable lead ports in both the commutators 22A, 22B and bearing plates 68 as will hereinafter be more fully described.

The construction of the commutators 22A, 22B utilized with the variable induction device of the present invention are more fully described with reference to Figures 5 and 6. Referring now to Figures 5 and 6, the commutators 22A, 22B preferably comprise a generally flat, circular plate 70 of an electrically non-conductive material and a segmented ring 72 of electrically conductive material. The segments 75 of the ring 72 are shown as being carried by the outer periphery of the plate 70 in electrical isolation from each other. An output terminal 73 may be electrically connected to one or more segments of the ring 72 at a convenient position.

An aperture 74 generally conforming to the shape of the legs 26A, 26B, a plurality of apertures 76 aligned with the positions of the threaded apertures 52 in the cylindrical members 24, and a plurality of lead ports 78 aligned with the lead ports in the cylindrical members 24, 24B may be provided through the plate 70. The segments 75 of the segmented ring 72 are electrically connected by a plurality of conductors 80, such that a closed, conductive loop is formed by the commutator segments 75 and the conductors 80.

As shown in Figure 2, the core 10 cross-sectional area is subdivided by the conductor crossover through the slots 27 in such a manner that the current induced by the field in pairs of conductors 80 is equal and opposite. Any grouping of pair conductors, even or odd, that accomplishes this may be utilized.

As illustrated in Figure 5, the current i induced in immediately adjacent segments 75 of the ring 72 is in the same direction in the segments. However, the segments are connected by the conductors 80 such that the currents i oppose and thus cancel. For example, the uppermost conductor 80 in Figure 5 connects the lower end of the uppermost segment 75 to the upper end of the adjacent segment 75. The voltages or emf's induced in the two connected segments are of opposite polarities at the points of connection which tends to cause opposing current flows in the uppermost conductor 80. The result is thus a current cancellation. By selecting the segments and the conductors 80 so that their total induced current tending to flow in one direction is equal to the total induced current tending to flow in the opposite direction, e.g. by selecting an even number of segments of substantially the same length and pair of conductors of substantially the same length, the total induced current flowing through the closed loop formed by the segments 75 and the conductors 80 is zero thereby eliminating commutator losses. Since the segments 75 and the conductors 80 form a continuous closed conductive path, the segments are all at the same potential and arcing does not occur as the brushes 20 bridge the gaps between segments in moving around the ring 72.

The assembling of the variable induction device of the present invention will now be described with reference to Figures 1 through 3. As illustrated in Figure 2, the one of the end members 12 of the core 10 is first removed, and the legs 26A and 26B may be inserted into the cavities 46A and 46B of the cylindrical members 24A and 24B, respectively. The drums 14A and 14B may then be mounted on the respective cylindrical members 24A and 24B with th ends thereof abutting the respective shoulders 54A and 54B. A bearing plate 68 having a leg receiving aperture 82, suitable lead ports 84 and a plurality of apertures 86 aligned with the like apertures in the commutators 22A, 22B as previously described, may be positioned on the end of each of the legs 26A, 26B in abutting relationship with the drums 14A, 14B. The commutators 22A and 22B may then be mounted on the respective legs 26A and 26B, the conductors 80 being disposed in the slots 27. The end member 12 may then be inserted between the laminations of the legs 26A, 26B and secured against removal by inserting the pins 28 therethrough.

The bearing plate 68 may, of course, be eliminated and the function thereof performed by providing a smooth bearing surface on one side of the commutators 22A, 22B. In addition, conventional fasteners such as flat head screws may be inserted through the apertures 76 in the commutator and the apertures 86 in the bearing plate 68 into the threaded apertures 52 in the cylindrical member 24 to provide additional strength. The induction device may then be secur d to a suitable frame (not shown) adjacent the manually or electrically driven gear 38 and the timing belt 32 may be mounted to circumscribe and engage the gear teeth 34 on the drums 14 and the gear 38 as illustrated in Figure 3.

The operation of the variable induction device of the present invention may be more fully understood with reference to the schematic diagram of Figure 7. Referring now to Figure 7, the coils are carried by the drums 14 are shown on the left side of the diagram and the coils carried by the cylindrical members 24 are shown on the right side of the diagram, as illustrated in phantom, to facilitate the description of

the operation.

The end 60A of the primary winding 56A may be electrically connected to the end 60B of the primary winding 56B and an a.c. input signal applied between the ends 58A and 58B of the respective primary windings 56A and 56B. Likewise, the ends 66A and 66B of the secondary transformer windings 62A and 62B, respectively, may be electrically connected, and an output voltage may be taken between the ends 64A and 64B of the respective windings 62A and 62B. This type of transformer connection may be referred to as a humbucking connection and is a desirable feature in a well designed transformer.

The fixed coil 40 having one end connected to the brush 20B and the other end 42 connected to the end of the overlying transferable coil 16B is preferably wound in a direction opposite from that of the transferable coil 16B, for example, in a counterclockwise direction looking from the left end of the drawing of Figure 1. The transferable coil 16B is connected in series opposition, and therefore the transferable coil 16A is in series aiding with the fixed coil 40.

In operation, the primary windings 56A, 56B are energized and induce an a.c. current into the secondary winding 62 62A, 62B and the coils 16A, 16B and 40. If the primary windings 56A, 56B are energized from a 115 volt a.c. line and if, as illustrated, the turns ratio between the primary windings 56 and the secondary windings 62 is 1:1, the voltage appearing between the ends 64A and 64B of the secondary windings 62A and 62B, respectively, will be 115 volts a.c.

Furthermore, if the total number of turns of the coils 16A, 16B and 40 is equal to the total number of turns of the coils 56 as illustrated, an output voltage which is variable between zero and 115 volts a.c. appears between the output terminals 73A and 73B on the commutators 22A and 22B, respectively. The maximum output voltage condition, i.e. 115 volts a.c. appearing between the output terminals 73A and 73B, may be obtained by synchronously rotating the drums 14A and 14B until all of the turns of the coil 16B have been transferred from the drum 14B to the drum 14A. Since the coil 16A is connected in series aiding to the fixed coil 40, the voltages across the coil 16A and the coil 40 add to produce a maximum or a 115 volt a.c. output voltage. Additionally, since at the maximum output voltage condition the fixed coil 40 and the coil 16A are wound on opposite drums, the variable secondary circuit is balanced, i.e. there are an equal number of turns on each drum.

The minimum output voltage condition may be obtained by rotating the drums in the opposite direction to transfer all of the turns of the coil 16A to the opposite drum. The coil 16B then has a maximum number of turns, and since the voltage induced thereacross is in series opposition with the voltage across the coil 40, the output voltage is a minimum or zero volts. It is, of course, apparent that any output voltage between zero and 115 volts a.c. may be obtained by rotating the drums 14A and 14B in the proper direction until the desired output voltage is obtained.

It is thus apparent from the above description that the variable induction device of the present invention provides an output voltage which is continuously variable between a predetermined maximum and minimum while providing isolation between the primary and secondary circuits. Also, the variable winding circuit is balanced at the full output voltage condition.

In addition, the induction device of the present invention is extremely versatile since the elements comprising the device may be easily removed and replaced with elements having various electrical characteristics. The secondary transformer windings 62A, 62B provide even further versatility since they may be connected in any number of ways to the variable secondary circuit or to independent loads.

The present embodiment is to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

WHAT WE CLAIM IS:—

1. A variable induction device comprising

a core of magnetic material having two substantially parallel legs,

a substantially cylindrical member non-rotatably mounted on each of the legs,

a substantially cylindrical, substantially hollow drum coaxially mounted on each of the members for axial rotation thereabout,

a first electrically conductive coil having a predetermined number of fixed turns wound in a predetermined direction about one of the drums,

electrical contact means carried by one end of each of the drums for rotation therewith, one of said said contact means being electrically connected to one end of said first coil,

an electrically conductive commutator carried by each of the legs in wiping engagement with the contact means,

a second electrically conductive coil having a predetermined number of turns wound about said drums, the said turns being transferable from one of the drums to the other of the drums in response to the rotation of the drums, one end of the second coil being electrically connected to the other end of the said first coil, the other end of the second coil being electrically connected to the other one of the contact means,

a transformer winding carried by the cylindrical members in electrical isolation from the first and second coils and in magnetic flux linking relation thereto, and

means for simultaneously axially rotating the drums about the cylindrical members to selectively modify the number of turns in the first coil effective to produce an output voltage by transferring the turns of the second coil from one drum to the other.

2. A variable induction device according to claim 1 wherein the core includes end members connected between the adjacent ends of the legs, one of the end members being removable to expose one end of each leg, thereby permitting the changing of the drums and the cylindrical members to achieve different electrical characteristics of the said inductive device.

3. A variable induction device according to claims 1 or 2 wherein the commutator comprises an electrically conductive segmented ring, the segments of which are electrically connected whereby currents induced in adjacent segments by a cyclically varying magnetic flux are substantially self-cancelling.

4. A variable induction device according to any of the preceding claims wherein the second coil when wound on the same drum as the first coil is wound radially outwardly of the first coil.

5. A variable induction device according to claim 1 wherein the first coil is embedded in the said one of the drums and the second coil is wound about the surfaces of the drums.

6. A variable induction device according to any of the preceding claims wherein the transformer winding comprises a primary transformer winding carried by the cylindrical members, and a seconday transformer winding carried by the cylindrical members in overlying relation to the primary transformer winding.

7. A variable induction device according to any of the preceding claims wherein the number of fixed turns of the first coil is equal to or greater than the total number of transferable turns of the second coil.

8. A variable induction device according to claim 1 wherein the transferable turns of the second coil on the said one drum are connected to the transferable turns of the second coil on the other drum in series opposition and wherein the transferable turns of the second coil on the said one drum are connected to the first coil in series opposition.

9. A variable induction device comprising

a magnetic core,

two spaced drums each mounted for axial rotation on said core,

an electrically conductive coil having a predetermined number of turns wound in a predetermined direction on one of the drums,

a transformer winding carried by the core in electrical isolation from the coil for generating a cylindrical varying magnetic flux linking the said coil,

means for axially rotating the drums, and

a coil wound on both drums for selective transference from one drum to the other in response to the rotation of the drums for modifying the number of turns of the electrically conductive coil effective to produce an output voltage.

10. A variable induction device according to claim 9 including electrical contact means mounted on each of the drums, and a commutator mounted on the core adjacent each of the contact means and in wiping electrical contact therewith.

11. A variable induction device according to claim 9 or 10 wherein the transformer winding is carried by two spaced cylindrical members mounted on the core.

12. A variable induction device according to claim 11 wherein each of the said drums is mounted substantially coaxially with an associated one of the said cylindrical members.

13. A variable induction device according to claim 11 including a secondary transformer winding of a predetermined number of fixed turns carried by at least one of the cylindrical members.

14. A variable induction device substantially as hereinbefore described with reference to the accompanying drawings.

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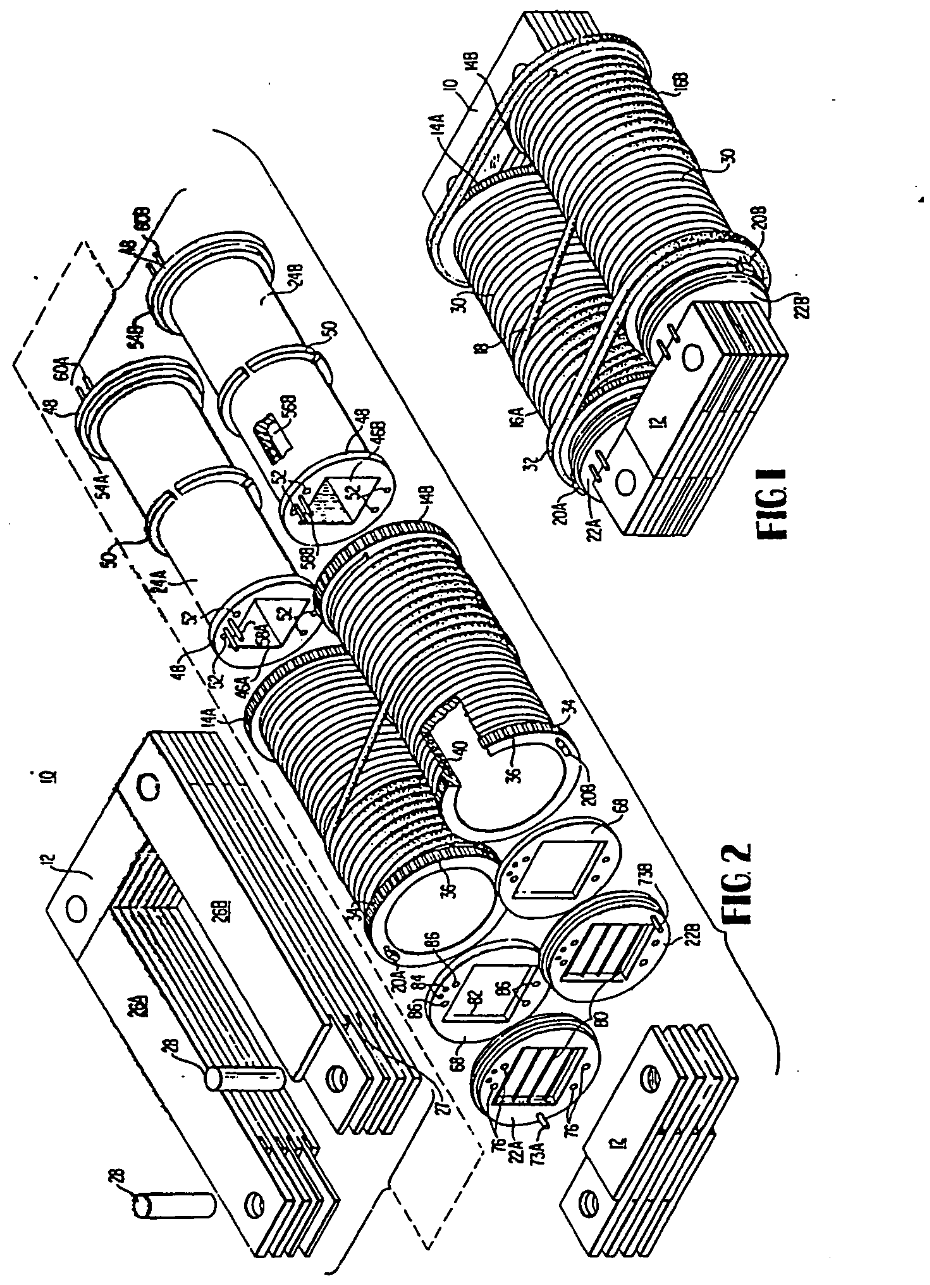


FIG 1

FIG 2

1341050 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

FIG 4

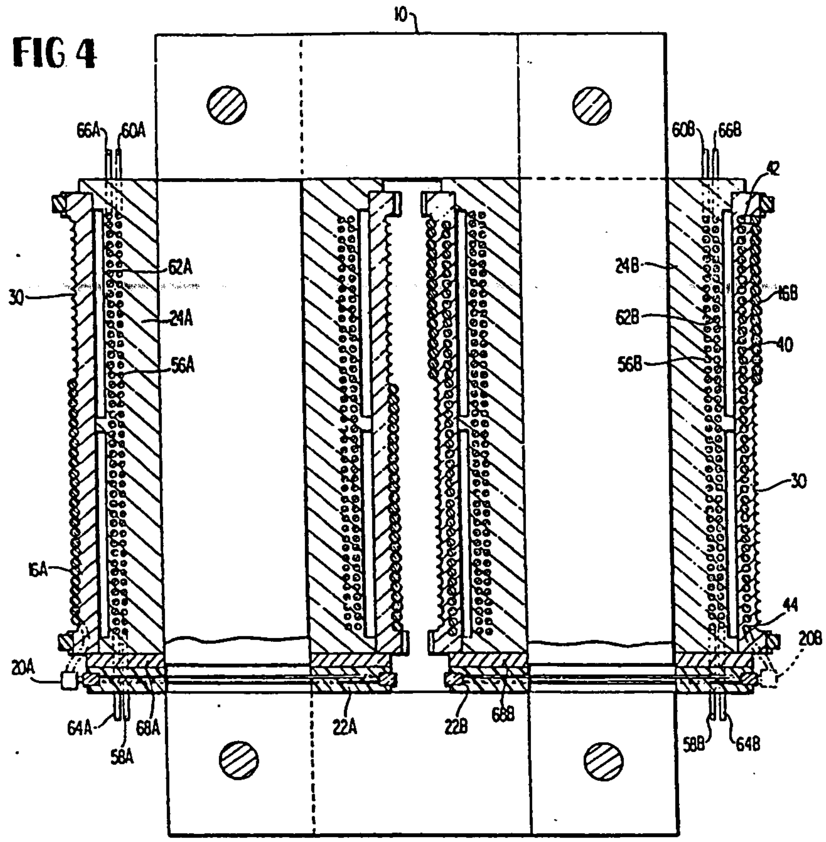
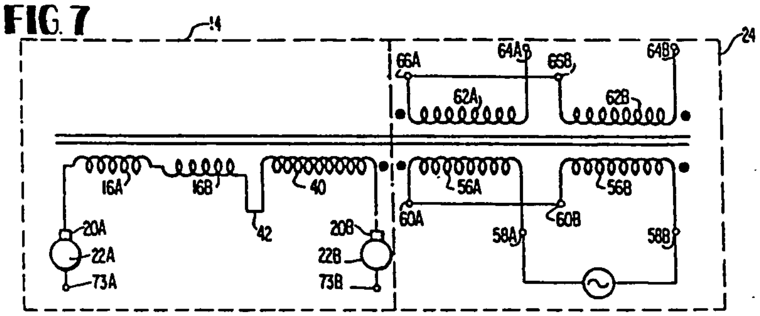


FIG 7



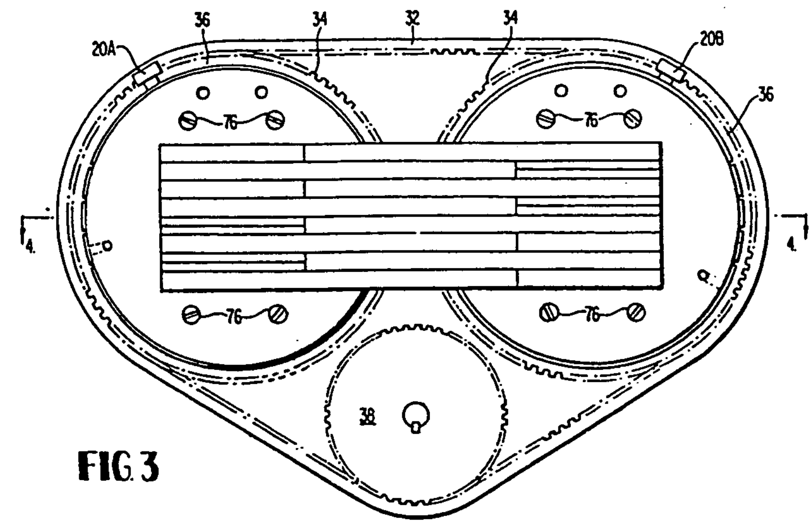


FIG 3

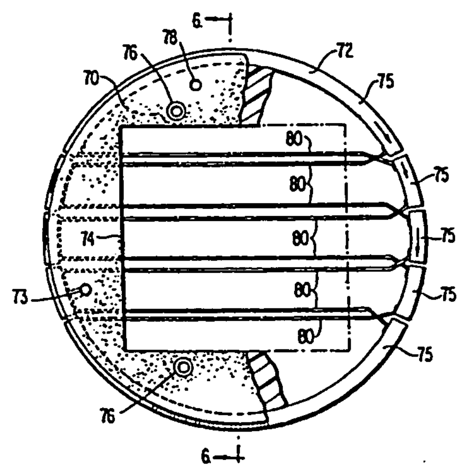


FIG 5

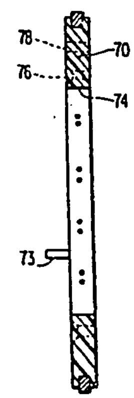


FIG 6